Marine Mammal Data Collection Procedures on Research Ship Line-Transect Surveys by the Southwest Fisheries Science Center

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I. Introduction

The Southwest Fisheries Science Center (SWFSC) has been conducting ship-based surveys of Pacific marine mammals since the mid 1970's (Smith 1979; Holt and Powers 1982). Line-transect methodologies (Hiby and Hammond 1989, Buckland et al. 1993) developed over this time are used to estimate absolute abundances of cetacean populations from visual sighting data. Genetic, photographic, acoustic, and behavioral information on cetaceans are also collected during these cruises. This report summarizes the field methods used to collect these data, with emphasis on the line-transect procedures.

Associated studies involving oceanography, seabirds, zooplankton, sea turtles, flyingfish and other surface fauna are typically also conducted on these surveys. Methods for these studies are detailed in SWFSC Technical Memoranda for each cruise, and are not described here.

II. SWFSC Line-transect History

The SWFSC began refining field methodologies for collecting line-transect data on cetaceans with early studies of the effects of the yellowfin tuna fishery in the eastern tropical Pacific Ocean (Smith 1982). These procedures have been used recently to produce estimates of absolute abundance for cetaceans in eastern tropical Pacific (Wade and Gerrodette 1992, 1993; Gerrodette 1999), and the U. S. West Coast Pacific (Barlow 1988, 1995, 1997; Forney et al. 1999); for the vaquita in the the Gulf of California (Jaramillo-Legorreta, et al. 1999); and for relative abundance of cetaceans in the western tropical Indian Ocean (Ballance and Pitman 1998).

The first SWFSC marine mammal research surveys to use line-transect methods were aerial surveys off Mexico and Central America, beginning in 1974 (Smith 1981). Early research ship surveys were calibrated in nearshore areas against the density estimates produced by line-transect surveys using aircraft in the same areas (Smith 1979, 1982). These calibrations were used to produce density estimates from ship sightings-per-mile in adjacent offshore areas that could not be surveyed by aircraft. The first estimates of the density of dolphin schools based directly on line-transect analysis of research ship data (rather than calibrating against aerial data) were for offshore eastern tropical Pacific surveys between 1977 and 1983 (Holt 1987). Estimates of inshore densities during this period were still based on aerial surveys.

The MOPS[1] survey program between 1986 and 1990 was the first by the SWFSC to produce abundance estimates for an entire cetacean population based solely on data from research ships rather than a combination of research ship, aerial survey, and tuna fishing vessel data. The basic equipment and survey procedures described in this report became standardized at that time, with the minor exceptions described below. These procedures allowed estimates of relative abundances (Holt and Sexton 1989a, 1989b; Sexton et al. 1991) and absolute abundances (Wade and Gerrodette 1992, 1993) of populations of dolphins and whales to be made using line-transect methods. A listing of SWFSC marine mammal research cruises using line-transect methods is given in Table 1 (see also Lee 1993, Barlow and Lee 1994).

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[1] Monitoring of Porpoise Stocks

III. Line-transect Field Equipment

A. Ships

Since 1986, most SWFSC surveys have been conducted from one or both of two National Oceanic and Atmospheric Administration (NOAA) ships, the *McArthur* and the *David Starr Jordan*. A third ship, the University-National Oceanographic Laboratory System (UNOLS) Ship *Endeavor*, was used in 1998. The NOAA Ship *Malcomb Baldridge* was used on a 1995 survey. Between 1977 and 1983 the NOAA Ships *David Starr Jordan* and *Townsend Cromwell* were regularly used. The NOAA Ships *Surveyor*, *Oceanographer,* and *Researcher* were occasionally used for marine mammal surveys between 1976 and 1983.

The *McArthur*, *Jordan*, *Endeavor*, and *Cromwell* range from 50 - 58 m in length. The *Surveyor*, *Oceanographer*, and *Researcher* were larger vessels, averaging about 90 m long. The *Baldridge* is 85 m long. Current surveys typically use the smaller ships and maintain cruising speeds of 18.5 km/hr (10 knots) through the water along pre-determined tracklines while actively searching for marine mammals. Survey speed may be modified for special projects. The larger ships sometimes surveyed at faster speeds, 20 – 25 km/hr (11 – 13 knots). The 1997 Vaquita survey was conducted at 11 km/hr (6 knots), and the 1997 SWAPS[2] project was conducted at 15 km/hr (8 knots).

B. Binoculars

Observers on these surveys typically use high power binoculars mounted on the ships' flying bridges to locate schools of marine mammals. The standard binocular configuration for detecting mammal schools consists of two 25 x 150 power "bigeye" binoculars mounted on the port and starboard sides of the ship's flying bridge (Figure 1). A third 25X binocular is often mounted near the center of the flying bridge for periodic use during sightings. Occasionally, a fourth, centrally located bigeye is used during cetacean sightings.

Handheld 7 x 50 binoculars are used during line-transect studies of harbor porpoise instead of 25X binoculars. Handheld 7 x 50 binoculars are also used on all surveys by the data recorder during searching effort, and often by other observers during closing mode, as described in the sections below.

Line-transect analysis methods use the perpendicular distance from the trackline (the ship's course) to each sighting. This is calculated using two measurements from the ship: 1) the angle between the trackline and the sighting; and 2) the shortest straight-line, or radial, distance to it. These are measured using a horizontal angle ring and reticle scale, respectively. In current surveys, the former is graduated in 1° increments and is either attached to the binocular mount (25X), or is an incremented pointer on the ship's railing in front of the observer (7X). The reticle scale (Figure 2) is inscribed in the binocular eyepiece. Reticles are converted to distance following the formulae given in Section V.

[2] Sperm Whale Abundnace and Population Survey

Before 1979, observers used 20X binoculars and estimated radial distances to sightings by eye. The binoculars were mounted in a sling that dampened vibration but also allowed some variability in horizontal position, reducing the precision of angle measurements. Angles were estimated with help from an angle ring located near each binocular. Angles were usually recorded in 5° increments. In 1979 25X binoculars began to be used on SWFSC surveys, and experiments were conducted to improve measurements of sighting angle and distance (Smith 1982). In 1980, an angle ring incremented in units of 1° was attached to the base of the binoculars, which were mounted on a rigid pedestal on the deck. Barlow and Lee (1994) examined patterns in the radial distance and angle estimates of the pre-1986 data for potential biases.

C. Data Entry

During the MOPS surveys and earlier, sighting and effort data were entered on paper forms in the field and recorded electronically at a later time. Between 1991 and 1996 several versions of the SWFSC data entry program, “CRUISE”, were used to record sighting, weather and effort data into a laptop computer on the flying bridge during the survey. Since 1996, these data are entered using the SWFSC software program "WinCruz"[3]. The computer is linked to the ship's global positioning system to record time and position for every event entered, such as a sighting or effort change, or automatically at a set interval, usually 10 minutes, if no other event has been entered.

WinCruz is used to monitor 16 different types of survey events (Appendix A). Each new event is represented by a new record in a textfile database. Keyboard function keys are used to record new events. Data are entered via a dialog box for each event containing the fields for that type of event. Appendix A displays the names and a brief description of each type of event and its associated data fields.

Beginning with the 1991 CAMMS[4] project, a mapping function showing the initial sighting locations relative to the moving ship was incorporated into the data entry program. By the 1996 ORCAWALE[5] survey, the WinCruz sighting map displayed sighting and resighting locations, along with projected school locations based on their speed and directions of travel. The computer is thus an aid to keeping track of the locations and movements of mammal schools interactively during the sighting sequence as well as serving as a data entry program. This can be particularly useful for relocating cryptic schools, or when more than one school is present.

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[3] available at << http://mmdshare.ucsd.edu/Software/Software.html>>
[4] California Marine Mammal Survey
[5] Oregon, California, Washington Line-Transect Experiment

IV. Line-transect Field Procedures

A. General survey

Observers conduct a visual watch for marine mammals during daylight hours (approximately 0600 to 1800). Observers rotate through 3 watch positions: port binocular, data recorder, and starboard binocular, typically shifting positions every 40 minutes. On special projects, additional watch positions may be designated. Prior to the 1991 CAMMS project, two 3-person observer teams alternated watches at 2 hour intervals. Since the 1993 PODS[6] survey a continuous rotation of 6 observers through the 3 positions has been used. At least one identification specialist with substantial experience in the survey area and with SWFSC survey methods is on watch at all times and takes the lead in deciding when to go on and off searching effort as described below.

On some surveys, secondary “tracking” or “independent observer” positions may be used to collect sighting data for comparison with the sightings made by the primary team. The methodologies for these projects are variable, but they are designed not to interfere with the procedures used by the primary team as described here.

Survey data is collected in one of two modes: 1) on-effort searching, and 2) off-effort "closing" to approach a school or conduct other sampling or data collection activities. During on-effort searching, the observers on watch actively scan the 180° forward of the ship for new sightings (Figure 1). Only sightings made during this on-effort mode are used in the line-transect estimates of abundance. During closing mode, observers focus on an already sighted school, gathering information to taxonomically identify the mammals, estimate school size and composition, and conduct ancillary data collection as described in the following sections. The tradeoff between these two modes, quantity of sightings versus quality of information per sighting, was examined during ORCAWALE by using a third, “passing” mode (continuous trackline searching effort without interruptions to approach schools) every third day of the survey (Barlow 1997). This allowed the improvement in data quality achieved during closing mode to be compared against the lost searching time and potential for underrepresenting high density areas while off-effort. The relative time spent in searching versus closing mode depends on survey objectives.

B. On-effort Searching Mode

Sighting data are collected only by the observers on watch in the designated watch positions during searching mode. Other personnel may be on the flying bridge, but no information from these personnel or from the auxiliary binocular positions about actual or potential sightings forward of 90° abeam is relayed to the primary team during searching. Any configuration other than the on-watch observers actively scanning for marine mammals is off-effort. The on-effort observers may be informed of missed sightings by other personnel once they are past 90° abeam, at which time they are entered as off-effort sightings.

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[6] Population of *Delphinus* Stocks

Each observer with a 25X binocular scans out to the horizon from 90° abeam of his/her side of the ship to 10° to the opposite side of the bow (100° in all). This provides coverage of the 20° along the ship's trackline by both observers while lateral regions are each covered by one observer. Observers are instructed to scan their entire area of responsibility in a consistent manner and not focus on particular regions. The details of scan rates and patterns (begin scanning at the trackline or the beam, etc.) are left to individual observer preference (Barlow 1999).

Using unaided eye and a handheld 7X binocular, the data recorder also searches the entire 180° forward of the ship, focusing on the trackline and the area from the ship out to about 400 meters (the "blind" area for observers using the 25X binoculars). The auxilliary 25X binoculars are not used to search for sightings, although they may be used by the data recorder to confirm the presence of a sighting once a cue has been seen using 7X or naked eye, and to observe distant schools during closing mode. The data recorder enters sighting, weather, navigation, searching effort, observer positions and other data into the laptop computer.

The ship may be directed by the mammal observers during searching mode to deviate by up to 30° from the planned trackline to avoid glare or rain squalls, returning to the original course once conditions have improved. Course deviations from the trackline while in on-effort mode to examine "interesting" areas such as floating debris that may attract cetaceans or other fauna are prohibited. Once such areas are past 90° abeam the observers may elect to enter "off-effort" mode and deviate from course to explore the area.

C. Sightings

A sighting is entered into WinCruz when the presence of a marine mammal at 0.1 reticles or closer has been confirmed by an observer. Sightings are assigned a unique identification number at this time. The distance to sightings at or over the horizon cannot be estimated with confidence (the difference between 0.0 reticles and 0.1 reticles for 25X binoculars from a 10 meter high platform is 2 miles) and they are not entered as sighting-events unless and until the mammals appear closer to the vessel. These distant sightings may be described as comments at any time, particularly if they are unlikely to be within 0.1 reticles from the vessel.

Prior to the 1993 PODS survey, sightings were entered at the time a "cue" (such as a bird flock or splash) was first seen. Cues that did not lead to confirmed sightings were deleted later. This method was changed after 1992 due to the uncertainty in associating a sighting with a cue several minutes after the cue was seen, given the potential movement of the mammals. In the case of a possible cue, observers are instructed not to neglect the rest of their area of responsibility by focusing on the region of the cue for more than a minute or so at a time while in searching mode.

The initial angle from the trackline (the ship's bow), left or right, read from the angle ring to the nearest degree, and distance (typically a reticle-reading) are recorded for each sighting, along with the sighting cue and related information (Appendix A). Occasionally, the initial angle and distance to sightings made by the recorder may be estimated by unaided eye. The initial bearing and distance to a school are usually based on the location of the first mammal seen. For many schools, few or no additional mammals are observable until several minutes after the school is first sighted, so no early estimate of the "center" of the school can be made. Information at the beginning of a distant sighting about the size and extent of a school is often limited. Early judgements may change in light of subsequent information as the sighting is approached. Schools are not always in a single aggregation throughout a sighting, and subgroups can separate and remerge with the rest of the school over time.

The effort is made to locate schools at as great a distance from the research vessel as possible, before they may have altered their position in response to it. An assumption of line-transect analysis is that the positions of the sightings have not been influenced by the survey platform prior to detection. Aerial studies of the response of dolphin schools to research ships indicate that while schools do move away from the trackline during the course of a sighting (Au and Perryman 1982), most are initially located by observers using 25X before the mammals have responded to the the ship (Hewitt 1985). Of the 19 dolphin schools tracked by helicopter in Hewitt's study, 14 did not respond to the survey vessel and 5 schools began moving away at an average distance of 2.0 nm (range 1.5 - 2.5 nm). The average radial detection distance for all dolphin schools during the 1999 STAR survey was 2.0 nm. The average for schools with fewer than 40 estimated individuals was 1.8 nm. For schools with 40 or more individuals the average was 2.4 nm. Issues regarding movement of schools as they are approached during the sighting sequence are discussed below.

If the sighting is located well ahead of the ship near the trackline and is easily visible, observers may stay in on-effort searching mode on the original trackline while they approach the mammals. In this case, each observer continues full scanning over the region they are responsible for rather than focusing on the sighting. If an extra person is available on the flying bridge, s/he may be assigned the task of keeping track of the school (but not searching for or commenting on other new sightings) while the primary team continues to search. Closing mode usually begins once the sighting is close enough to begin identifying and estimating the number of individuals in the school or if a second on-effort sighting is made. In the case of multiple sightings, the nearest on-effort sighting rather than the earliest seen is typically approached first.

D. Off-effort Closing Mode

Sightings are approached if they are within three nautical miles perpendicular to the trackline. Sightings at greater distances are sometimes approached if they are of special interest. Effort typically switches to closing mode following a confirmed sighting, and the start of an off-effort sequence is recorded on the computer. Observers focus their attention on the region of the sighting. Variable speeds and courses may be taken during closing mode in order to approach the mammals.

Sightings of new schools while in off-effort mode are recorded as off-effort sightings. Attention is not focused on these sightings while closing on an on-effort sighting. After finishing data collection for the on-effort sighting, an off-effort sighting may be approached if it is a priority species for biopsy, photography, or other ancillary projects. If an off-effort school is resighted later after returning to searching mode, it is recorded as an on-effort sighting (see "Resuming Searching Mode" section below).

E. School Subgroups versus New Sightings

Determining whether two or more groups of mammals should be defined as subgroups of the same school or as separate schools can be difficult at the start of a sighting. Schools are defined as part of the sighting process for the purpose of estimating abundance. This does not necessarily imply social or behavioral interactions. The question is whether the mammals are traveling together as a group with only temporary separations of subgroups from the main body during the sighting sequence, or will continue to be distinctly separate groups throughout the period necessary to identify them and estimate their numbers. A few animals initially sighted at two distinct locations might turn out to be the separate ends of a continuous group of mammals as the area is approached. Conversely, what initially appeared to be a scattered school of mammals can turn out to be distinctly separated groups of different species at closer examination.

Generally, the approach used in the field in distinguishing between separate sightings and subgroups of the same sighting is to enter what initially appear to be separate groups as different sightings. As the sighting progresses, if the groups can no longer be distinguished and none appear to have left the area, the putative sightings are merged into one by deleting the second sighting-event. This allows all observers to estimate the number of individual mammals in the same defined area at the closest approach of the ship rather than trying to account for a possible earlier separation that is no longer evident when the best estimates of abundance and composition can be made.

For some species such as long-diving whales, determining whether a surfacing animal has already been detected and assigned a sighting number or is a new sighting can be difficult. New sightings are assigned only when there is no doubt that the mammal or group of mammals has not already been assigned a sighting number. If there is any doubt, the animal(s) in question are considered a part of the already entered sighting and observer estimates of abundance reflect the uncertainty about whether the individual animals may already have been counted.

Determining whether currently visible animals are resightings of a previous surfacing or are being seen for the first time can also be difficult when making course changes through an area containing a dispersed dolphin school (i.e., has a subgroup already been encountered?) A related issue for sightings of diving animals that may be submerged for 40-50 minutes (i.e., sperm whales) is deciding how many total animals are in a non-synchronously diving group. The SWAPS project found the estimated group size for some pods of sperm whales increased when 90 minutes, versus 10 minutes, was spent with the sightings (Taylor 2000).

F. Taxonomic Identifications

Observers identify cetaceans to the level of species/stock when possible. For management purposes, a stock is a management unit smaller than a species that may be defined biologically (a population or subspecies) or using geographic boundaries useful for management. A hierarchical classification system of sighting-categories that can be distinguished in the field is employed (Appendix B), from the most certain identifications at the level of an individual stock or sighting-category to the most general, “unidentified cetacean”.

Taxonomic assignments during the survey are based on field-observable morphological characteristics. Assignments are conservative in that the most general category that can be assigned with certainty, rather than a more specific classification that may be likely but questionable, is used. The only exception to the morphology-based classification is for sightings of the genus *Globicephala*, which can be difficult to distinguish to species in the field and are all classified based on geographic location as *G. macrorhynchus* when they occur north of the equator in the Pacific, where *G. melas* is not known to occur.

Typically, observers determine the taxonomic classification(s) of the sighting by consensus, with the identification specialist making the final determination in disputed cases. The school may be "mixed", containing more than a single sighting-category. The occurance of a general category such as "unidentified dolphin" with a more specific category, such as a species or stock, indicates the observers had some evidence that separate species may have been present, not that all individuals in the school were not clearly seen. If not all individuals were clearly seen but there is no indication from the ones that were seen that more than a single species was present, the school is coded as belonging to the single category that was identified. By definition, multiple stocks of the same species are not found in the same school.

The marine mammal sighting form (Appendix C) completed for each sighting contains a drawing and brief narrative of the features used in determining the identification, along with behavioral notes. It is initiated by the observer who first made the sighting, with additional notes and sketches by any observers who have more information. The sighting form contains enough information on morphological and other characterisitics to justify the level of identification made in the field.

Sightings classified to a broad category such as “unidentified dolphin” are prorated during the analysis into management stocks (Gerrodette 1999). As an aid to this process, observers may indicate “possible” or “probable” identifications in the sighting-form narrative, in addition to the confirmed identification entered in the electronic datafile. These unconfirmed identifications from the sighting-form are later entered into the database in a separately identifiable format from the confirmed identifications.

G. School Size and Percent Composition Estimates

Each observer on watch estimates the number of mammals in the school, all taxa combined. If more than one taxon is present, percent composition of each sighting-category in the school is also estimated independently by each observer. These estimates of school size and percent composition are independent in that no discussion of them among observers occurs at any time. Off-duty observers can also make estimates if they got a good look at the school. The estimates are recorded by each observer in personal notebooks, which are collected and entered into the database by the cruise leader or other non-observer scientist at the end of each day.

Each observer makes three estimates of abundance for each school, "best", "high" and "low". The high and low estimates define the range within whose limits the observer is confident the school's abundance falls. In rare cases, only a low estimate is possible. Methods of estimating the number of individuals in a school vary, from direct counts for a small school, to counting groups estimated to comprise some number of individuals as a unit (i.e. "groups of ten"), to making a single estimate for an entire school seen at a distance. The method used varies by individual observer and school behavior according to circumstances surrounding the sighting. During closing mode, the attempt is to approach schools as closely as possible for as long a period as observers need to make their estimates. This isn't always possible due to evasive behavior or other conditions, such as weather or restrictions on vessel movement, that can result in losing contact with a sighting. In these cases observers make their estimates based on the information they have, perhaps using a more general sighting-category and/or wider range between high and low estimates of abundance than for a school that was better observed.

Since 1987, observer estimates have been checked against aerial photographs of schools photographed from a helicopter on the *Jordan* while the observer estimates of school size were being made. All mammal observers on the ship make estimates of these calibration schools, including those who would normally be off-duty. Observer estimates are subsequently compared to laboratory counts of the individual mammals in the photographs (Gerrodette and Perrin 1991). A linear regression of each observer's 3 estimates per school is fitted to the photogrammetric counts, resulting in individual calibration factors for each observer. Observers are not informed about the values of their calibrations but are instructed to continue estimating school sizes in the most consistent manner possible. New observers without sufficient photogrammetric calibrations are calibrated against observers for whom photogrammetric counts have been obtained (Barlow et al. 1998).

Observers are instructed and tested during pre-cruise training sessions using several methods to estimate abundance. Since 1979, observers have practiced estimating dots on a screen and other objects, including individuals in aerial photographs of cetacean schools, with advice on counting methods and feedback about the true number of individuals. After practice in estimating abundance, observers are tested using the same kinds of visual displays. In 1999, a computer-based training and testing program, "GroupSize"[7] was developed and used. Results from these training methods are compared to the photogrammetric calibrations of observer counts.

H. Resuming Searching Mode

While in off-effort mode, ancillary projects such as 35 mm photo-identification and skin biopsy sampling may be conducted (see below). Upon completion of activities associated with the sighting, the ship returns to searching mode on a course parallel to the original trackline unless this is greater than 10 nm (18.5 km) from it, in which case the ship resumes searching on a 20° course back to the original trackline. On-effort searching is not resumed until the ship has come

[7] available at << http://mmdshare.ucsd.edu/Software/Software.html>>

up to survey speed and there is no chance of mistaking the previous sighting for a new one. Either all individuals from the sighting are left behind the ship before resuming searching effort or the locations of remaining subgoups forward of 90° are clearly identified.

Once on-effort searching mode has resumed, if a resighting is made of a school previously entered as an off-effort sighting, a new sighting event is entered for the school. Both the original off-effort and subsequent on-effort sighting-events are retained, with comments in the database and on the sighting forms that they were the same school. School size and composition estimates proceed as usual, in off-effort mode if necessary.

V. Sighting Distance Calculations

Converting reticles to distance depends on the distance to the horizon (which in turn is dependent on height above water) and a reticle conversion factor (degrees/ or radians/reticle). The underlying theory is covered in Lerzack and Hobbes (1998). The computational algorithm described here was derived from Visual Basic code provided by Laake[8].

A. Distance to Horizon

The viewing distance to the horizon in kilometers, *H*, follows the relationship;

$$H = \sqrt{2\text{rh} + \text{h}^2} \tag{1}$$

where

r = radius of earth in km = 6371,
h = binocular height above sea surface in kilometers.

Total binocular height above the water for the *McArthur* and for the *Endeavor* is 10.4 meters, giving a ship-to-horizon sighting distance of approximately 11.5 km (6.2 nm). On the *Jordan*, binocular height above water is 10.7 meters, giving a sighting distance of approximately 11.7 km (6.3 nm). The binocular height on the *Baldridge* is 15.5 m for a distance of 14.1 km (7.6 nm). The *Cromwell* has a binocular height of 6.1 meters, giving a maximum sighting distance of approximately 8.9 km (4.8 nm). The *Surveyor* was 11 m above water for a sighting distance of 11.9 km (6.4 nm), and the *Oceanographer* and *Discoverer* were 16.3 m high for a maximum sighting distance of 14.4 km (7.8 nm).

Prior to 1994, the binocular height was fixed and observers stood on an adjustable stand. Adjusting for observer height differences with this system was mechanically awkward. Between 1994 and 1996 the observer stands were gradually replaced by binocular stands that are adjustable to observer height. This means that binocular height above water is not fixed, but the effect on viewing distance is minor, creating variations of up to about 0.1 nautical miles in the maximum viewing distances for a 10 m platform.

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[8] Jeff Laake, Alaska Fisheries Science Center

B. Converting Reticles to Distance

The reticle scale is a vertical series of equally-spaced horizontal lines (Figure 2). To measure the distance to animals in the water, the uppermost reticle is placed at the horizon and the number of reticles below the horizon to the sighting is counted. This reticle value is entered into WinCruz, which calculates the radial distance from the ship to the sighting. Radial distance is calculated using a *reticle conversion factor*, the number of degrees or radians per reticle (radians are converted to degrees by multiplying by $180/\pi$). Smith (1982) measured the conversion factor for the 25X binoculars used by SWFSC as 0.0823 degrees/reticle. Kinzey and Gerrodette (In review) conducted a series of reticle measurements of the conversion factor, *C*, in radians:

$$C = \frac{L}{n\,D} \tag{2}$$

where

L = length of target,
n = number of reticles spanned by the target,
D = distance between target and binocular.

Kinzey and Gerrodette found a more accurate value for the 25X conversion factor is 0.0771 degrees/reticle (0.00135 radians/reticle). The maximum difference in the calculated radial distance between 25X conversion factors of 0.0823 and 0.0771 for a 10 m high platform occurs at 0.5 reticles and is about 0.1 nautical mile (the differences between calculated distances for other reticle values falls to zero in either direction from 0.5 reticles). The reticles in two styles of 7X binocular were also measured and slight differences in the value of the conversion factor between the binocular styles, of 0.279 and 0.286 degrees/reticle (0.00487 and 0.00499 radians/reticle, respectively) were found. These differences between 7X reticle scales correspond to maximum differences in sighting distance of about 0.03 nautical miles (Table 2).

The height above water, reticle conversion factor, and number of reticles to a sighting are used to calculate the radial sighting distance, *R* :

$$R = (r + h)\sin(\alpha + \rho\,C) - \sqrt{r^2 - [(r + h)\cos(\alpha + \rho\,C)]^2} \tag{3}$$

where

h = binocular height in km,
r = radius of earth in km = 6371,
α = atan(H/r) where H is distance to horizon in kilometers as calculated in eq. (1),
ρ = reticle reading,
C = radians/reticle, as calculated in eq. (2).

Table 2 and Figure 3 display the calculated distances for reticle values from 0.1 to 20 reticles below the horizon for a 5 m, 10.7 m, and 15 m high platform.

Once the radial distance to a school is calculated from eq. (3) and the angle from the trackline to the school is measured by the observer using the angle ring on the binocular mount, the perpendicular distance in kilometers to the sighting from the trackline, *P*, is calculated as:

$$P = R \sin \theta \tag{4}$$

where

R = radial distance from eq. (3),

θ = horizontal angle between trackline and sighting.

C. Early SWFSC Distance Calculations and Experimental Measurement Systems

In 1982 a reticle-to-distance formula for the reticle scale in the 25X binoculars was developed based on spherical geometry (Smith 1982). Smith's formula was used to calculate distances from reticle readings until 1986. The formula overestimated distance, especially near the horizon (Barlow and Lee 1994). A modified version was developed by Barlow in 1987 by forcing Smith's formula to fit radar-measured distances for given reticle values. The parameter values representing platform height and binocular conversion factor in the formula were selected to fit the radar distances instead of using their measured values. Unbiased fits of 7X and 25X reticle readings to the radar distances were achieved.

Barlow's formula produced results for the specific combination of binocular height and reticle values used with the radar data. New platform heights or reticle scales would require additional measurements against radar to establish new parameter values empirically. In 1994, Laake's computational form (eq. 3) of Lerzack and Hobbes (1998) formula was substituted for Barlow's formula for radial distance on SWFSC surveys. This formula uses the measured values of platform height and binocular conversion factor. All calculations of distance from reticle values for the cruises listed in Table 1 now use equation 3.

An experimental, computer-aided mechanical system for determining angles and distances to sightings was examined from 1981 through the 1989 MOPS survey. This CAST (Computer Assisted Sighting Technology) system integrated sighting angles with ship course and heave-roll-pitch information to calculate initial bearing and distance to sightings. The system was cued via an electrical switch when an observer was actively tracking a school. CAST required dolphin schools to move at a constant course and speed in order to calculate distance. Irregular school movement and problems with maintaining visual contact during the required tracking period resulted in very few distance estimates obtained with high confidence (Hill and Gerrodette 1992) and the system was discontinued.

The ability of a digital video imaging system to measure radial sighting distances was evaluated during PODS 1993. A Cohu Monochrome 1/2" CCD Camera (Model 4915-2100/ES75)[9] was mounted on the bigeyes. Digital images were captured and sent to a PC at the start of a sighting by the observer using a toggle switch when the sighting was in view. Global Lab Image 2.2 Beta software was used to process the images. Equation 3 was modified to use pixels below the

[9] Use of trade or product names does not imply endorsement by NMFS.

horizon instead of reticles. While the system was capable of measuring distances to large objects such as an inflatable boat, the resolution proved inadequate to distinguish objects the size of a dolphin fin at the sighting distances visible to an observer using 25X binoculars.

VI. Ancillary Projects

A. Biopsy Sampling

In order to analyze the genetic distinctiveness and relationships among and between populations and broader taxonomic groupings of cetaceans, biopsy tissue samples are collected during the surveys using a hollow-tipped dart fired from a crossbow. A small plug of skin and blubber is obtained that can subsequently be analyzed for toxicological and hormonal studies as well as the primary studies of genetics. Cetaceans are sampled either from the ship's bow as they bow ride (dolphins), or are approached by the ship (whales), or from a small boat (whales and dolphins). The small boat is generally a rigid-hulled inflatable with outboard motor(s) launched from the larger ship.

Biopsy samples are prepared for storage as quickly as possible after they are obtained. This may be storage in a dimethyl sulfoxide (DMSO) solution or a -80° F freezer, possibly after quick-freezing in liquid nitrogen. The sighting number corresponding to the line-transect survey is recorded for each sample.

B. 35 mm Photography

During closing mode 35 mm photographs of dolphins and whales are taken from the survey vessel or from a smaller boat, often in conjunction with biopsy sampling. Dolphin photographs aid in stock identification and studies of geographic variation. Photographs of individually identifiable whales can additionally be used as an alternative means of estimating population size using recapture methodologies, as well as determining migration patterns and stock identification.

The sighting number of each school or individual photographed is recorded along with other notes about the photographed cetaceans. Potentially identifiable whale photographs are distributed to the curators of various whale identification catalogs after the end of the cruise.

C. Cetacean Acoustics

Recordings of cetacean vocalizations using sonobuoys, and the development of methods for detecting and locating cetaceans using towed arrays of hydrophones, are ongoing. An acoustic array for detecting cetaceans was towed behind a SWFSC research ship as early as 1982 (Holt 1983). Since the 1992 PODS survey, sonobuoys have been deployed in the vicinity of known sightings to record whale or dolphin calls.

During the 1997 SWAPS project, a hydrophone array was towed behind the ship to detect and locate acoustically-active sperm whales for comparison with sightings by the visual team

(Barlow and Taylor 1998). Sonobuoys were also used during SWAPS to produce higher resolution recordings than those produced by the array. A hydrophone array and sonobuoys were used during the 1998 SPAM[10] survey, and sonobuoys during the 1999 STAR[11] project. The STAR 2000 survey will employ both an array and sonobuoys.

D. Cetacean Behavior

Opportunistic observations of cetacean behavior have been recorded as a narrative on the marine mammal sighting form by observers since the MOPS surveys. A more structured recording of behavioral observations of dolphin schools was added to the back page of the marine mammal sighting form in 1999, emphasizing behavioral responses of schools to the research ships (Appendix C).

Acknowledgements

Several scientists furnished historical details that aided in the preparation of this report. In particular, David Au, Jay Barlow, Al Jackson, and Bob Pitman provided information on the specific timing and development of equipment and methods used prior to the MOPS surveys. These contributions expanded on the information found in the publications listed below.

[10] *Stenella* Population Abundance Monitoring
[11] *Stenella* Abundance Research

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Table 1. SWFSC marine mammal research ship cruises using line-transect methods. This table does not include marine mammal cruises on which line-transect data were not recorded.

Cruise no.	Year	Dates	Ship	Region	Project	Bino. power	Angle meas.[1]	Dist. meas.[2]	km[3]
84	1974	02Jan-26Feb	*Jordan*	ETP	-	20X	eye	eye	6535
168	1976	05Jan-03Mar	*Cromwell*	ETP	SOPS	20X	eye	eye	9967
207	1976	05Oct-18Nov	*Jordan*	ETP	-	20X	eye	eye	880
212	1976	15Nov-09Dec	*Surveyor*	ETP	Ship Avoidance	20X	eye	eye	4348
213	1977	04Jan-08Mar	*Jordan*	ETP	SOPS	20X	eye	eye	11169
214	1977	06Jan-25Mar	*Cromwell*	ETP	SOPS	20X	eye	eye	14174
232	1977	24Mar-15Apr	*Oceanographer*	ETP	Equatorial Dist.	20X	eye	eye	3668
234	1977	06Apr-02May	*Zharkii*						2820
310	1977	27Jun-29Jul	*Oceanographer*	ETP	Equatorial Dist.	20X	eye	eye	3759
319	1977	03Oct-21Nov	*Jordan*	ETP	Equatorial Front	20X	eye	eye	8974
428	1978	02Aug-29Sep	*Regina Maris*	ETP	-	20X	eye	eye	2414
463	1979	03Jan-15Mar	*Jordan*	ETP	SOPS	25X	5˚ ring	eye	11262
464	1979	03Jan-15Mar	*Cromwell*	ETP	SOPS	20X	eye	eye	11318
564	1979	27Sep-24Oct	*Jordan*	CA	Calif. Current	25X	5˚ ring	eye	4429
598	1980	03Jan-05Mar	*Jordan*	ETP	SOPS	25X	5˚ ring	eye	9845
599	1980	03Jan-05Mar	*Cromwell*	ETP	SOPS	20X	1˚ ring	eye	9724
642	1980	21Mar-19Apr	*Oceanographer*	ETP	EPOCS	25X	1˚ ring	eye	4414
646	1980	17Jun-11Jul	*Jordan*	CA	Calif. Current	25X	1˚ ring	eye	3962
648	1980	21Jul-25Sep	*Researcher*	Carib, ETP	EPOCS	25X	1˚ ring	reticles	4595
687	1981	20Jan-01Apr	*Oceanographer*	ETP	EPOCS	25X	1˚ ring	reticles	5417
716	1982	19May-29Jul	*Oceanographer*	ETP	EPOCS	25X	1˚ ring	reticles	7939
798	1982	05Apr-21Apr	*Jordan*	CA	-	25X	1˚ ring	reticles	2174
801	1982	15May-03Aug	*Jordan*	ETP	-	25X	1˚ ring	reticles	11080
843	1983	12Jan-13Apr	*Jordan*	ETP	Ship Avoidance	25X	1˚ ring	reticles	12156
852	1983	03Mar-11Apr	*Surveyor*	ETP	Ship Avoidance	25X	1˚ ring	reticles	1088
874	1983	05Dec-11Dec	*Jordan*	CA	-	25X	1˚ ring	reticles	816
895	1984	04Sep-15Sep	*Jordan*	CA/OR/WA	HPorp	25X/7X	1˚ ring	reticles	1598
905	1984	05Dec-19Dec	*Jordan*	CA	-	25X	1˚ ring	reticles	1421
910	1985	24Jan-09Feb	*McArthur*	CA/OR/WA	HPorp	7X	pointer	reticles	1657
942	1985	03 Sep-17Sep	*Jordan*	CA/OR	HPorp	7X	pointer	reticles	2009
970	1986	24Apr-05May	*Jordan*	CA	HPorp	7X	pointer	reticles	1329
989	1986	29Jul-05Dec	*McArthur*	ETP	MOPS	25X	1˚ ring	reticles	16397
990	1986	29Jul-05Dec	*Jordan*	ETP	MOPS	25X	1˚ ring	reticles	13931
1080	1987	30Jul-10Dec	*McArthur*	ETP	MOPS	25X	1˚ ring	reticles	14847
1081	1987	08Aug-10Dec	*Jordan*	ETP	MOPS	25X	1˚ ring	reticles	13753
1164	1988	28Jul-06Dec	*Jordan*	ETP	MOPS	25X	1˚ ring	reticles	11000
1165	1988	28Jul-06Dec	*McArthur*	ETP	MOPS	25X	1˚ ring	reticles	13363
1267	1989	28Jul-06Dec?	*Jordan*	ETP	MOPS	25X	1˚ ring	reticles	12690

[1] indicates whether 20X or 25X sighting angles were estimated by "eye" (sometimes assisted using a nearby angle ring); a collar-mounted 5˚ ring (again assisted by a nearby angle ring), or using an angle ring attached to a pedestal-mounted binocular. For 7X surveys, a "pointer", a nearby angle ring incremented in units of 1˚, is used.
[2] distance estimates by eye versus reticle measurements.
[3] number of kilometers completed in on-effort searching mode.

Table 1 (continued)

1268	1989	29Jul-07Dec	*McArthur*	ETP	MOPS	25X	1˚ ring	reticles	14748
1369	1990	28Jul-06Dec	*Jordan*	ETP	MOPS	25X	1˚ ring	reticles	13501
1370	1990	28Jul-06Dec	*McArthur*	ETP	MOPS	25X	1˚ ring	reticles	18939
1426	1991	28Jul-05Nov	*McArthur*	CA	CAMMS	25X	1˚ ring	reticles	10382
1467	1992	28Jul-02Nov	*McArthur*	ETP	PODS	25X	1˚ ring	reticles	8363
1468	1992	28Jul-02Nov	*Jordan*	ETP	PODS	25X	1˚ ring	reticles	7201
1508	1993	28Jul-06Nov	*McArthur*	CA-MX	PODS	25X	1˚ ring	reticles	8504
1509	1993	28Jul-06Nov	*Jordan*	CA-MX	PODS	25X	1˚ ring	reticles	10029
1546	1994	21Jul-31Aug	*Surveyor*	N. Pacific	AIMMS	25X	1˚ ring	reticles	2898
-	1995	21Mar-26Jul	*Baldridge*	Indian	-	25X	1˚ ring	reticles	9784
1600	1995	03Aug-01Sep	*McArthur*	CA	WHAPS	25X	1˚ ring	reticles	3458
1601	1995	06Sep-08Nov	*McArthur*	Gulf CA	CADDIS	25X	1˚ ring	reticles	6123
1602	1995	13Nov-05Dec	*McArthur*	CA/OR/WA	HPorp	7X	pointer	reticles	1478
1603	1996	10Jul-04Aug	*Jordan*	CA	WHAPS	25X	1˚ ring	reticles	1705
1604	1996	14Jul-06Nov	*McArthur*	CA/OR/WA	ORCAWALE	25X	1˚ ring	reticles	9324
1605	1996	04Sep-04Nov	*Jordan*	CA/OR/WA	ORCAWALE	25X	1˚ ring	reticles	5600
1606	1997	11Feb-04Mar	*McArthur*	CA	T-TOP	25X	1˚ ring	reticles	1128
1607	1997	08Mar-09Jun	*McArthur*	NE. Pacific	SWAPS	25X	1˚ ring	reticles	12232
1608	1997	04Aug-19Sep	*Jordan*	Gulf CA	VAQ	25X	1˚ ring	reticles	2815
1609	1997	15Oct-30Oct	*Jordan*	CA	T-TOP2	25X	1˚ ring	reticles	600
1610	1998	31Jul-09Dec	*McArthur*	ETP	SPAM	25X	1˚ ring	reticles	14379
1611	1998	30Jul-09Dec	*Endeavor*	ETP	SPAM	25X	1˚ ring	reticles	15563
1612	1998	31Jul-09Dec	*Jordan*	ETP	SPAM	25X	1˚ ring	reticles	12344
1613	1999	28Jul-09Dec	*Jordan*	ETP	STAR	25X	1˚ ring	reticles	13894
1614	1999	28Jul-09Dec	*McArthur*	ETP	STAR	25X	1˚ ring	reticles	16989

Table 2. Radial distances (nm) calculated for given reticle values using equation 3 from a 5 m, 10.7 m and 15 m high platform for 25X binoculars, and from a 10.7 m platform for two styles of 7X binoculars.

Reticles	**Eq. 3 25X 5m**	**Eq. 3 25X 10.7m**	**Eq. 3 25X 15m**	**Eq. 3 new 7X 10.7m**	**Eq. 3 old 7X 10.7m**
0.0	4.31	6.30	7.40	6.30	6.30
0.1	2.72	4.31	5.26	3.06	3.09
0.2	2.26	3.69	4.56	2.32	2.34
0.3	1.97	3.28	4.09	1.89	1.92
0.4	1.76	2.98	3.74	1.61	1.63
0.5	1.59	2.74	3.46	1.40	1.42
0.6	1.46	2.54	3.23	1.24	1.26
0.7	1.35	2.38	3.03	1.12	1.14
0.8	1.26	2.24	2.86	1.02	1.04
0.9	1.18	2.11	2.71	0.93	0.95
1.0	1.11	2.00	2.58	0.86	0.88
1.2	0.99	1.81	2.35	0.75	0.76
1.4	0.90	1.66	2.17	0.66	0.68
1.5	0.86	1.60	2.08	0.63	0.64
1.6	0.82	1.54	2.01	0.59	0.61
1.8	0.76	1.43	1.88	0.54	0.55
2.0	0.70	1.33	1.76	0.49	0.50
2.2	0.66	1.25	1.66	0.45	0.46
2.5	0.60	1.15	1.52	0.41	0.41
2.8	0.55	1.06	1.41	0.37	0.37
3.0	0.52	1.01	1.35	0.34	0.35
3.5	0.46	0.90	1.21	0.30	0.31
4.0	0.41	0.81	1.10	0.27	0.27
4.5	0.37	0.74	1.00	0.24	0.24
5.0	0.34	0.68	0.92	0.22	0.22
6.0	0.29	0.59	0.80	0.18	0.19
7.0	0.25	0.52	0.71	0.16	0.16
8.0	0.23	0.46	0.63	0.14	0.14
9.0	0.20	0.42	0.57	0.12	0.13
10.0	0.18	0.38	0.52	0.11	0.11
11.0	0.17	0.35	0.48	0.10	0.10
12.0	0.16	0.32	0.44	0.09	0.10
13.0	0.14	0.30	0.41	0.09	0.09
14.0	0.13	0.28	0.39	0.08	0.08
15.0	0.13	0.26	0.36	0.08	0.08
16.0	0.12	0.25	0.34	0.07	0.07
17.0	0.11	0.23	0.32	0.07	0.07
18.0	0.11	0.22	0.31	0.06	0.06
19.0	0.10	0.21	0.29	0.06	0.06
20.0	0.10	0.20	0.28	0.06	0.06

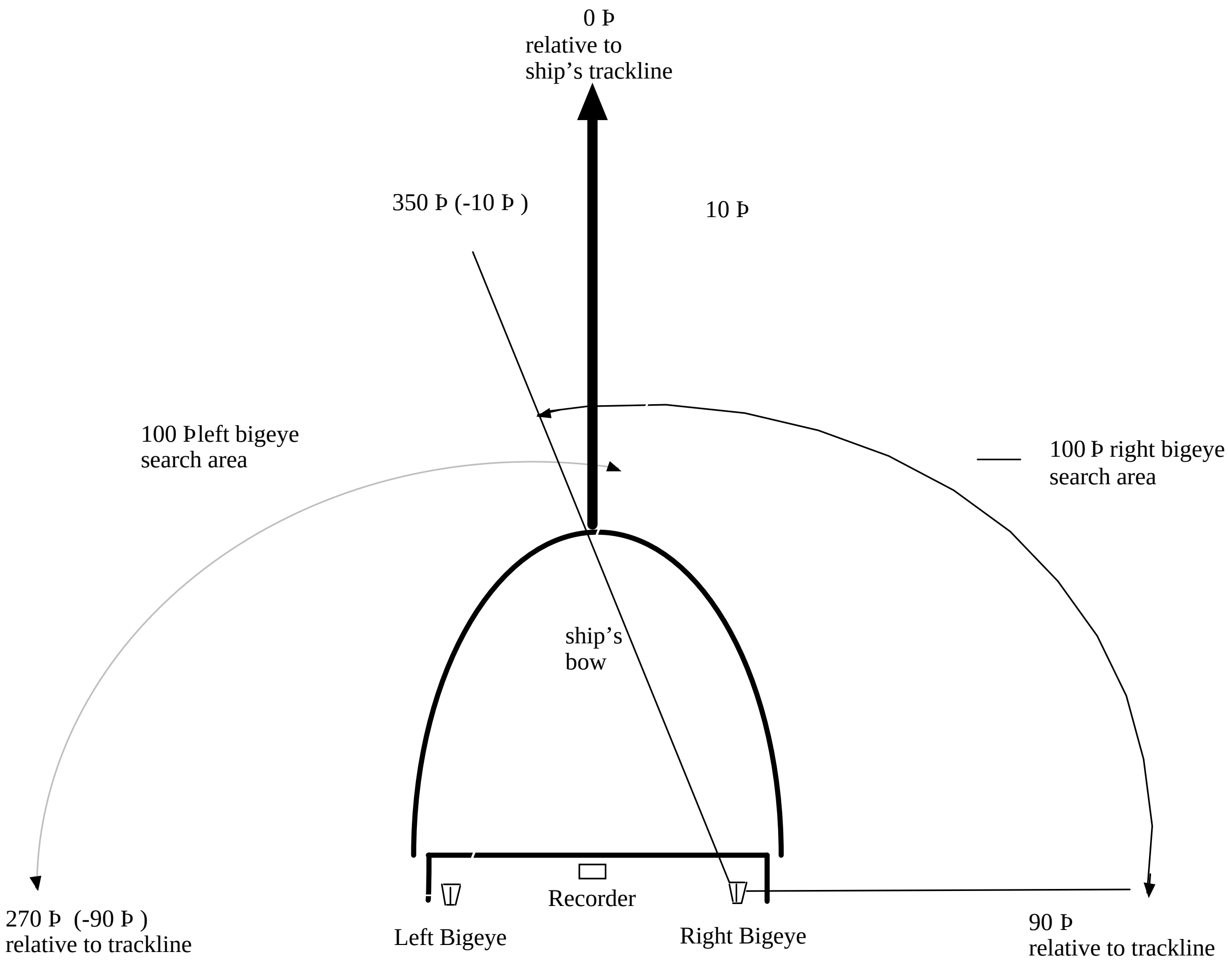

Figure 1. Locations of primary 25X binoculars on flying bridge and trackline coverage during searching mode. Recorder also searches entire 180 ° forward of ship with naked eye and 7X binocular.

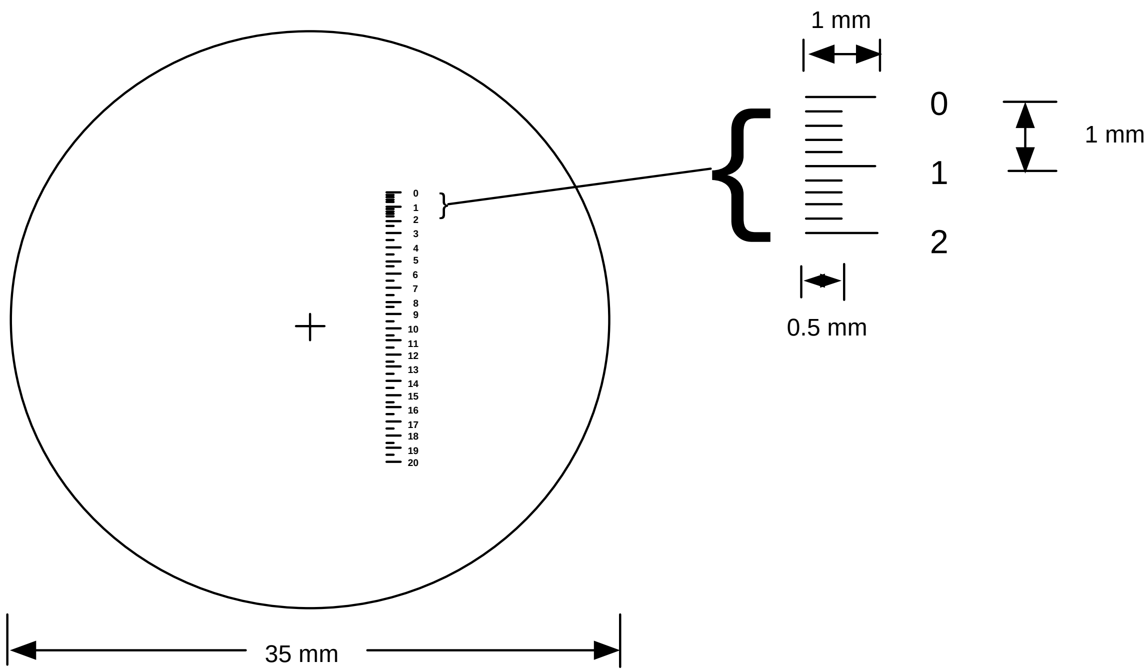

Figure 2. The reticle scale inscribed in the 25X binoculars used by the Southwest Fisheries Science Center.

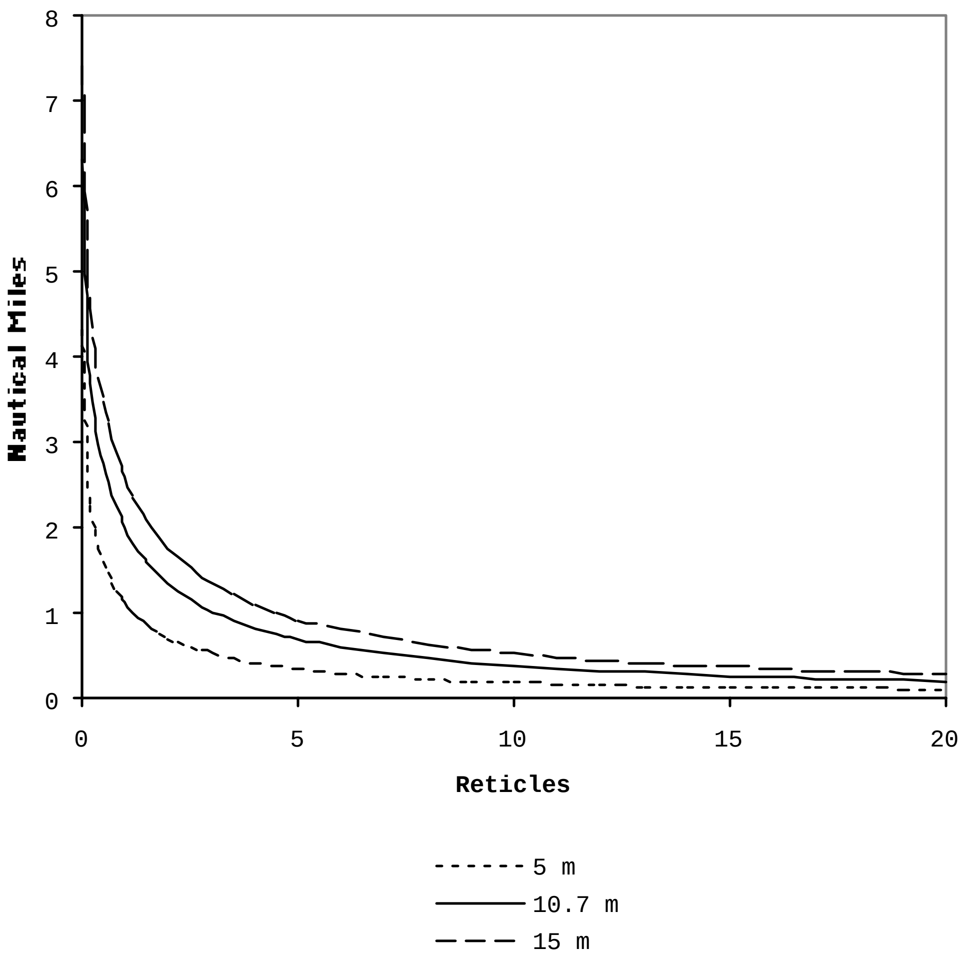

Figure 3. Distances for given reticle readings from a 5 m, 10.7 m and 15 m high platform for 25X binoculars. Numerical values from Table 2.

Appendix A – WinCruz Events

The WinCruz data entry program maintains a database of the 16 different types of sighting and effort events that are monitored during the survey. One additional event (the "r" event, below) is recorded by data editors during the editing process.

New events are entered in one of two ways during the survey: 1) by an observer via a keyboard function key representing either an individual event or, for some function keys, an associated cluster of events; 2) a position is recorded automatically by the program at a set interval (typically 10 minutes) if no other events have been entered. The function keys and their associated events are listed along the bottom of the program window.

Each event is represented in the database as a new line which begins with the associated time, date, and position fields, automatically entered by the program via GPS input. In addition to these automatic fields, some other event-specific fields require typed input by the user as described below. An interactive dialog box appears on the screen for each event to accept input for that event's data fields. The dialog box lists the coding options available for each of the event's fields when the field's text entry box is selected.

The data fields for an event can be entered or modified later by reselecting the letter representing that event in an event buffer visible on the program's screen and entering the data. Later entries or changes to an event do not alter the original time and position fields, which always refer to the time the function key for the event was first entered. If multiple events occur at once in the field, the function keys for each can be entered and then the data fields filled in later when there is time.

Bold letters in the list below represent the type of event, followed by the associated function key in parentheses.

B (F3) *begin effort*. The first time the "F3" function key is typed after starting the program indicates searching effort has begun. This event accepts four values as input:

1) cruise number - the number assigned to the cruise.
2) passing/closing mode - indicated by the character "p" or "c".
3) GMT offset - the difference in hours between local time and GMT.
4) Echosounder - (EQ50) status.

R (F3) *resume effort*. Resume on-effort searching mode after being off-effort. Same function key as the "begin effort" event. Automatic GPS fields only, no manually-entered data fields.

r (F3) *resume effort*. A lower-case r in the database indicates effort was conducted following on-effort protocols but not on a planned trackline. This event code is entered during the data editing process, not the field.

E (F5) *end effort*. End on-effort searching mode to close on a sighting, end the day, or for some other reason. No manually-entered fields.

P (F6) *observer positions*. Normally 3 manually-entered fields (can be modified to accept additional positions on special projects):

1) LtObsID – left bigeye observer code.
2) RecObsID – recorder observer code
3) RtObsID – right bigeye observer code.
4) IndObsID – independent observer, if present.

V (F7) *sea state viewing conditions*. 5 manually-entered fields:

1) Beaufort – beaufort sea state.
2) Swell Height – height of predominant swell in feet.
3) Swell Direction – compass direction of predominant swell
4) Water Temperature –water temperature, normally left blank.
5) Wind Speed – true wind speed in knots

N (F8) *navigation information*. This event has two fields that can be entered manually but are normally calculated automatically by the program from GPS data.

1) Course – direction the ship is moving, course made true. This can differ from the ship's heading (the direction the bow is pointing) at slow speeds during off-effort closing due to currents and wind. In order for the mapping function to accurately reflect the position of a sighting relative to the bow under these conditions, the ship's heading can be substituted for course by entering heading and clicking "hold" in the map display window.
2) Speed – ship's speed over ground

W (F9) *weather information*. 5 manually-entered fields:

1) Rain/Fog - code indicating presence of rain, fog, or haze.
2) Horizontal Sun –code for horizontal sun angle.
3) Vertical Sun –code for vertical sun angle.
4) Wind Direction – wind direction in degrees, relative to true North.
5) Visibility – distance in nautical miles at which a dolphin could be seen surfacing with the water (not sky) as background.

S (F2) *marine mammal sighting*. 8 manually-entered fields: [note: when tracker data is collected, tracker sightings get an M (match of previous sighting) or m (possible match with previous sighting) code later in the data editing process for this event.]

1) Sight # - the 4-digit sequential sighting number (a default consecutive value is entered by WinCruz)
2) Observer ID – the 3-digit observer code
3) Cue – 1-digit code for the sighting cue
4) Sighting method – the 1-digit code for the method by which the school was detected.
5) Bearing – the horizontal angle between the trackline and sighting in degrees
6) Reticle – the distance in reticles below the horizon to the sighting. Reticle scale must be from the type of binocular entered in field #4, “sighting method”.
7) Distance NM – the radial distance to the sighting in nautical miles (automatically calculated by the program from reticles but can be entered directly if no reticle reading is available).
8) Course – course the school is moving relative to the vessel’s trackline.
9) Speed – estimated speed of the school.

A (F2) *auxiliary sighting information*. This event automatically follows every sighting event, or “S” line, and contain details pertaining to the sighting. 8 manually-entered fields:

1) Sight# - the 4 digit sequential sighting number (WinCruz enters the default value)
2) W.Temp – not used
3) PhotoY/N – were photographs taken of the school?
4) BirdsY/N – were birds present with the school?
5) Spp1Code – The 3-digit species code (Appendix C).
6) Spp2Code – The species code if a second taxa is present.
7) Spp3Code – The species code if a third taxa is present.
8) Spp4
Code – The species code if a fourth taxa is present.

Observer estimates of abundance and species composition are entered from observer greenbooks in 1 – 4 lines following the auxillary “A” event line by the cruise leader at the end of the day.

s (shift-F2) *sighting position update*. A resighting of a previously sighted school with updated bearing and distance information. Can be used to track school movement with the mapping function. 5 manually-entered fields:

1) Sight# - the sighting number assigned to the original sighting.
2) Bearing - the bearing to the sighting in degrees.
3) Reticle – the distance in reticles below the horizon to the sighting.
4) DistNMI - the radial distance to the sighting in nautical miles .
5) Course – course the school is moving relative to the vessel’s trackline.

t (F4) *turtle sighting*. a turtle sighted by the mammal team or birders. 9 manually-entered fields:

1) ObsID – ID code for the observer that made the sighting.
2) Spp – 2-character taxonomic code
3) Bearing – the bearing in degrees to the turtle.
4) DistNMI – the distance in tenths of a nautical mile to the turtle.
5) #turtles – the number of turtles.
6) AssocJFR – the code for associated flotsam.
7) Reticle – the 25X reticle value if available.
8) Size – observer estimate of whether the turtle is an adult or juvenile.
9) Caught? – yes or no

F (shift-F4) *fishing boat sighting*. 4 manually-entered fields:

1) ObsID – the observer who made the sighting
2) Bearing – bearing to fishing boat
3) DistNMI – the distance in nautical miles (calculated by WinCruz if the reticle field below is filled).
4) Reticle – 25X reticles below horizon

C (F10) *comment*. Comments can be entered at any time.

Q *tracking team position*s. used during special projects.

1) LtObsID
2) RtObsID
3) RecObsID

***** *automatic position record* (every 10 min.)

(F1) *deleted event*. Use of the F1 function key deletes whichever event was selected in the event buffer.

APPENDIX B - 1999 Sighting Category Codes

001	MESOP_PERU	Mesoplodon peruvianus	Pygmy beaked whale
002	OFFSH_SPOT	Stenella attenuata (offshore)	Offshore pantropical spotted dolphin, offshore spotter
003	UNID_SPINR	Stenella longirostris (unid. subsp.)	Unidentified spinner dolphin, spinner porpoise
004	CLYMENE	Stenella clymene	Clymene dolphin, short-snouted spinner dolphin
005	UNID_COMM	Delphinus sp.	Unidentified common dolphin, saddleback dolphin, whitebelly porpoise
006	COAST_SPOT	Stenella attenuata graffmani	Coastal spotted dolphin, spotter, silverbacks
007	SOTALIA	Sotalia fluviatilis	Tucuxi, Guiana dolphin
008	ORCAELLA	Orcaella brevirostris	Irrawaddy dolphin, Lumbalumba
009	SPECTACLED	Australophocaena dioptrica	Spectacled porpoise
010	EAST_SPINR	Stenella longirostris orientalis	Eastern spinner dolphin
011	WBEL_SPINR	Stenella longirostris (whitebelly)	Whitebelly spinner dolphin
012	WHITE-BEAK	Lagenorhynchus albirostris	White-beaked dolphin
013	STRIPED	Stenella coeruleoalba	Striped dolphin, streaker porpoise, euphrosyne dolphin
014	A_WHT_SIDE	Lagenorhynchus acutus	Atlantic white-sided dolphin
015	STENO	Steno bredanensis	Rough-toothed dolphin, Steno
016	LONGB_COMM	Delphinus capensis	Baja neritic common dolphin, long beaked common dolphin
017	SHRTB_COMM	Delphinus delphis	Offshore common dolphin, short-beaked common dolphin
018	TURSIOPS	Tursiops truncatus	Bottlenose dolphin, black porpoise, common porpoise
019	HEAVISIDES	Cephalorhynchus heavisidii	Heaviside's dolphin
020	HECTORS	Cephalorhynchus hectori	Hector's dolphin, pied dolphin, white front dolphin
021	GRAMPUS	Grampus griseus	Risso's dolphin, gray grampus
022	P_WHT_SIDE	Lagenorhynchus obliquidens	Pacific white-sided dolphin, lag, hookfin porpoise
023	PEALES	Lagenorhynchus australis	Peale's dolphin, blackchin dolphin
024	HOURGLASS	Lagenorhynchus cruciger	Hourglass dolphin
025	DUSKY	Lagenorhynchus obscurus	Dusky dolphin
026	FRASERS	Lagenodelphis hosei	Fraser's dolphin, Sarawak dolphin
027	LISSO_BOR	Lissodelphis borealis	Northern right whale dolphin
028	LISSO_PER	Lissodelphis peronii	Southern right whale dolphin
029	BLACK_DOL	Cephalorhynchus eutropia	Black dolphin, Chilean dolphin
030	COMMERSONS	Cephalorhynchus commersonii	Commerson's dolphin, piebald dolphin
031	MELON_HEAD	Peponocephala electra	Melon-headed whale, Hawaiian/many-toothed blackfish, electra dolphin
032	PYGMY_KLLR	Feresa attenuata	Pygmy killer whale, slender blackfish
033	FALSE_KLLR	Pseudorca crassidens	False killer whale
034	GLOBI_SPP	Globicephala sp.	Unidentified pilot whale
035	LONG_PILOT	Globicephala melas	Long-finned pilot whale, Atlantic pilot whale, blackfish, pothead
036	SHRT_PILOT	Globicephala macrorhynchus	Short-finned pilot whale, blackfish, pothead
037	KILLER_WHA	Orcinus orca	Killer whale
038	SOUSA_CHIN	Sousa chinensis	Indo-Pacific hump-backed dolphin, white dolphin
039	SOUSA_TEUS	Sousa teuszii	Atlantic hump-backed dolphin
040	HARBR_PORP	Phocoena phocoena	Harbor porpoise, herring hog
041	VAQUITA	Phocoena sinus	Vaquita, Gulf of California harbor porpoise
042	BURMEISTER	Phocoena spinipinnis	Burmeister's porpoise, black porpoise
043	BL_FINLESS	Neophocaena phocaenoides	Black finless porpoise
044	DALLS_PORP	Phocoenoides dalli	Dall's porpoise
045	BELUGA	Delphinapterus leucas	White whale, beluga, belukha, sea canary

Appendix B. Sighting codes (continued)

046	SPERM_WHAL	Physeter macrocephalus	Sperm whale
047	PYGMYSPERM	Kogia breviceps	Pygmy sperm whale
048	DWARFSPERM	Kogia sima	Dwarf sperm whale
049	ZIPHIID_WH	ziphiid whale	Unidentified beaked whale
050	HYPERO_PLN	Hyperoodon planifrons	Southern bottlenose whale, flathead bottlenose whale
051	MESOP_SPP	Mesoplodon sp.	Unidentified Mesoplodon
052	MESOP_CARL	Mesoplodon carlhubbsi	Hubb's beaked whale, archbeak whale
053	MESOP_HECT	Mesoplodon hectori	Hector's beaked whale
054	MESOP_BOWD	Mesoplodon bowdoini	Andrew's beaked whale, deepcrest whale
055	MESOP_EURO	Mesoplodon europaeus	Gervais' beaked whale, Antillean beaked whale
056	MESOP_BDNS	Mesoplodon bidens	Sowerby's beaked whale
057	MESOP_GNKO	Mesoplodon ginkgodens	Ginkgo-toothed beaked whale
058	MESOP_GRAY	Mesoplodon grayi	Gray's beaked whale
059	MESOP_DENS	Mesoplodon densirostris	Blaineville's beaked whale, dense-beaked, tropical beaked whale
060	MESOP_LAYA	Mesoplodon layardii	Strap-toothed whale
061	ZIPHI_CAVI	Ziphius cavirostris	Cuvier's beaked whale, goose-beaked whale
062	BERARD_ARN	Berardius arnuxii	Arnoux's beaked whale, southern giant bottlenose whale
063	BERARD_BAI	Berardius bairdii	Baird's beaked whale, northern giant bottlenose whale
064	TASMA_SHEP	Tasmacetus shepherdi	Shepherd's beaked whale
065	MESOP_PACI	Mesoplodon pacificus	Longman's beaked whale, Indo-Pacific beaked whale
066	N_RIGHT_WH	Eubalaena glacialis	Northern right whale
067	BOWHEAD_WH	Balaena mysticetus	Bowhead whale
068	PYGMY_RGHT	Caperea marginata	Pygmy right whale
069	GRAY_WHALE	Eschrichtius robustus	Gray whale
070	UNID_RORQL	Balaenoptera sp.	Unidentified rorqual
071	MINKE_WHAL	Balaenoptera acutorostrata	Minke whale
072	BRYDES_WHL	Balaenoptera edeni	Bryde's whale
073	SEI_WHALE	Balaenoptera borealis	Sei whale
074	FIN_WHALE	Balaenoptera physalus	Fin whale
075	BLUE_WHALE	Balaenoptera musculus	Blue whale
076	HUMPBACK_W	Megaptera novaeangliae	Humpback whale
077	UNID_DOLPH	unid. dolphin	Unidentified dolphin or porpoise
078	UNID_SM_WH	unid. small whale	Unidentified small whale
079	UNID_LG_WH	unid. large whale	Unidentified large whale
080	KOGIA_SPP	Kogia sp.	Unidentified Kogia - dwarf or pygmy sperm whale
081	MESOP_STEJ	Mesoplodon stejnegeri	Steinger's beaked whale, sabertooth, Bering Sea beaked bhale
082	MESOP_MIRU	Mesoplodon mirus	True's Beaked Whale
083	MESOP_SP_A	Mesoplodon sp. A	Unnamed beaked whale
084	HYPERO_AMP	Hyperoodon ampullatus	Northern Bottlenose, North Atlantic bottlenose whale
085	NARWHAL	Monodon monoceros	Narwhal, sea unicorn
086	S_RIGHT_WH	Eubalaena australis	Southern right whale
087	FRANCISCAN	Pontoporia blainvillei	Franciscana, La Plata dolphin
088	C_A_SPINNR	Stenella longirostris centroamericana	Central American spinner dolphin, Costa Rican spinner dolphin
089	UNID_SPOT	Stenella attenuata/plagidon	Unidentified spotted dolphin in Atlantic
090	UNID_SPOT	Stenella attenuata (unid. subsp.)	Unidentified pantropical spotted dolphin, spotter porpoise
091	AT_SPOTTED	Stenella frontalis	Atlantic spotted dolphin, spotter porpoise
092	GANGES_DOL	Platanista gangetica	Ganges susu, Ganges dolphin

093	INDUS_DOL	Plantanista minor	Indus susu, Indus dolphin
094	INIA	Inia geoffrensis	Boto, Amazon river dolphin
095	LIPOTES	Lipotes vexillifer	Baiji, Chinese river dolphin, whitefin dolphin
096	UNID_CETAC	unid. cetacean	Unidentified cetacean
097	UNID_OBJCT	unid. object	Unidentified object, possible marine mammal
098	UNID_WHALE	unid. whale	Unidentified whale
099	SEI/BRYDES	Balaenoptera borealis/edeni	Rorqual identified as a Sei or Bryde's whale
100	TRESMARIAS	Stenella longirostris (Tres Marias)	Tres Marias spinner dolphin
101	SW_SPINNER	Stenella longirostris (southwestern)	Southwestern spinner dolphin
102	GRAYS_SPIN	Stenella longirostris longirostris	Gray's spinner dolphin, pantropical spinner dolphin
103	E/CA_SPIN	Stenella longirostris orient/centroam	Undetermined eastern or Central American spinner dolphin
AA		Arctocephalus australis	South American fur seal
AG		Arctocephalus galapagoensis	Galapagos fur seal
AT	GUAD_FURSL	Arctocephalus townsendi	Guadalupe fur seal
AZ		Arctocephalus gazella	Antarctic fur seal
CU	NO_FURSEAL	Callorhinus ursinus	Northern fur seal
EB		Erignathus barbatus	Bearded seal
EJ	STELLAR_SL	Eumetopias jubatus	Stellar sea lion
EL		Enhydra lutris	Sea otter
HG		Hydrodamalis gigas	Stellar sea cow
MA	N_ELEPHN_S	Mirounga angustirostris	Northern elephant seal
OB	SA_SEALION	Otaria byronia	South American sea lion
OR		Odobenus rosmarus	Pacific walrus
PF		Phoca fasciata	Ribbon seal
PH		Phoca hispida	Ringed seal
PL		Phoca largha	Spotted seal
PU	UNID_PINNI	unid. pinniped	Unidentified pinniped
PV	HARBR_SEAL	Phoca vitulina	Harbor seal
TI		Trichechus inunguis	Amazon manatee
TM		Trichechus manatus	West Indian manatee
UA	UNID_FURSL	unid. fur seal	Unidentified fur seal
UO	UNID_OTARI	unid. sea lion	Unidentified sea lion
US	UNID_SEAL	unid. seal	Unidentified seal
ZC	CA_SEALION	Zalophus californianus	California sea lion
CC		Caretta Caretta	Loggerhead sea turtle
CM		Chelonia mydas/agassizi	Green/Black sea turtle
DC		Dermochelys coriacea	Leatherback sea turtle
EI		Eretmochelys imbricata	Hawksbill sea turtle
LK		Lepidochelys kempi	Kemp's Ridley turtle
LV		Lepidochelys olivacea	Olive Ridley sea turtle
ND		Natator depresus	Flatback turtle
UH		Other than D. coriacea	Unidentified hardshell sea turtle
UT		Chelonidae	Unidentified sea turtle

Appendix C

SWFSC Marine Mammal Sighting Form

NOTES: w/ ANGLE

Date ___/___/___ (Y Y M M D D)   Cruise # ________   Sighting # ________

Time ________   Effort   ON   OFF   Observer # ________

SPECIES DETERMINATION

	CODES
1.	
2.	
3.	
4.	

ASSOCIATED ANIMALS:
List ID and number of other species near the sighting.

DIAGNOSTIC FEATURES: Describe and sketch the shape, size and markings of the species identified.

BEHAVIOR: Describe the aggregations, movements, blows, etc. of the animals.

School Movement:
Initial Speed ________   Direction relative to bow ________   Closest Distance ________

Calibration Y N   Bow Riding Y N   Biopsy Y N   Photographs Y N

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★ U.S. GPO: 1997-581-635/40256

BEHAVIORAL OBSERVATIONS

Closest distance between dolphins and vessel: ________

In your estimation, when first observed,
were the animals already reacting to the research vessel? Y N U O

I. Group Behavior

Behavior when first observed (circle all that apply):

fast traveling	moderate traveling	slow traveling	milling	associated swimming	unknown	other

Did the behavior change during observation? Y N U O

If the behavior changed, what did the behavior change to (circle all that apply)?

fast traveling	moderate traveling	slow traveling	milling	associated swimming	unknown	other

II. School Shape

Were individuals spaced: tight loose unknown other

If loose, were the individuals: uniform clumped unknown other

III. School Composition

Calves present? Y N U O

IV. Reaction to the Vessel

Approach the boat?	Y	N	U	O
Bow ride?	Y	N	U	O
Run from the boat?	Y	N	U	O
Low swimming?	Y	N	U	O
Did the school split?	Y	N	U	O
If yes, did the subgroups move off in different directions?	Y	N	U	O

If yes, and it's a mixed school, is the subgroup composition: mixed single species unknown other

V. In your estimation, relative to the research vessel, was this school:

evasive non-evasive both unknown other

Key: Y = yes N = no U = unknown/cannot be determined O = other, please explain